



الهندسة من أجل الصلاح



Al-Mustaqbal University

Collage of Engineering

Prosthetics and Orthotics Engineering

Second Stage

PRINCIPLES OF PROSTHETICS AND ORTHOTICS

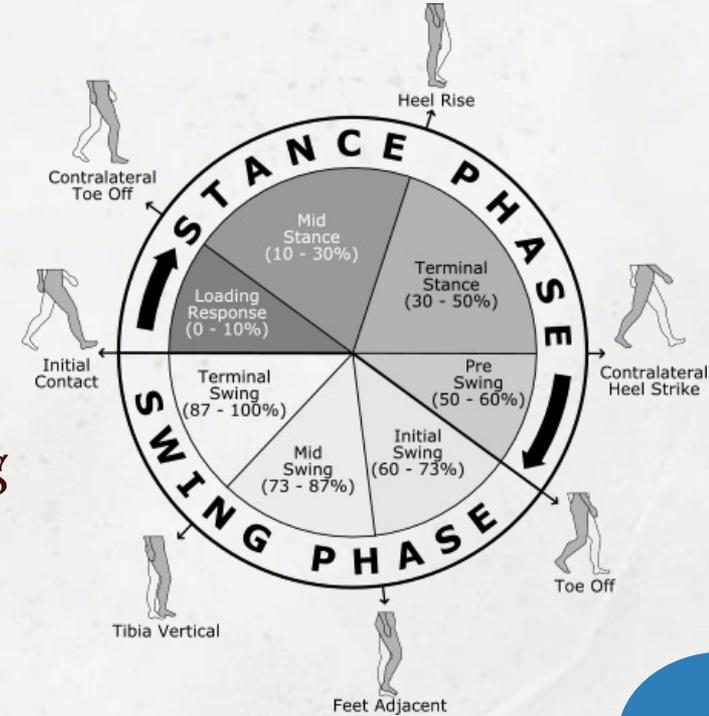
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Basics of Normal Gait



Normal Gait: a series of rhythmical, alternating movements of the trunk and limbs which results in the forward progression of the center of gravity.

One Gait Cycle: the period of time from one heel strike to the next heel strike of the same limb.

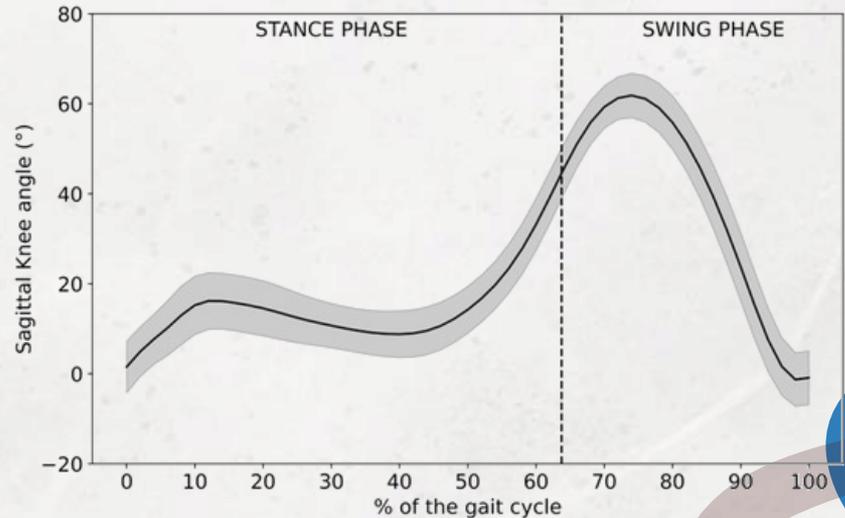
The gait cycle consists of two main phases for each foot:

Stance Phase ($\approx 60\%$):

- Begins when the heel of one leg strikes the ground.
- Ends when the toe of the same leg lifts off the ground.

Swing Phase ($\approx 40\%$):

- The period between toe-off and the next heel strike of the same foot.



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Time Frame of the Gait Cycle



A. Stance vs. Swing

- Stance Phase = ~60% of the gait cycle

When the foot is in contact with the ground

- Swing Phase = ~40% of the gait cycle

When the foot is off the ground and moving forward

B. Single vs. Double Support

- Single Support = ~40% of the gait cycle

Only one foot is in contact with the ground

- Double Support = ~20% of the gait cycle

Both feet are in contact with the ground at the same time



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Stance Phase

1- Heel Contact (Initial Contact)

The heel first touches the ground.

2- Foot-Flat (Loading Response)

The forefoot makes initial contact with the ground, body weight begins to shift onto the limb.

3- Midstance

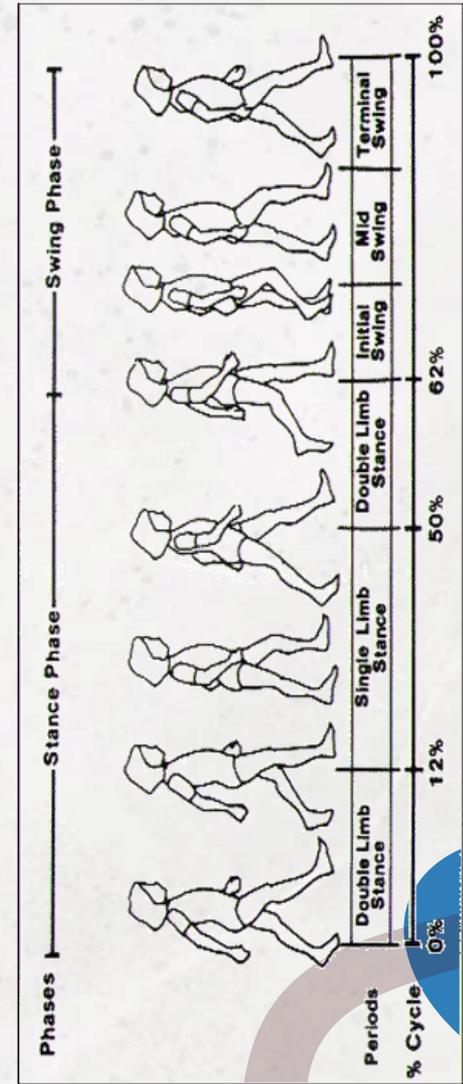
The body's center of gravity (greater trochanter) is aligned vertically over the supporting foot.

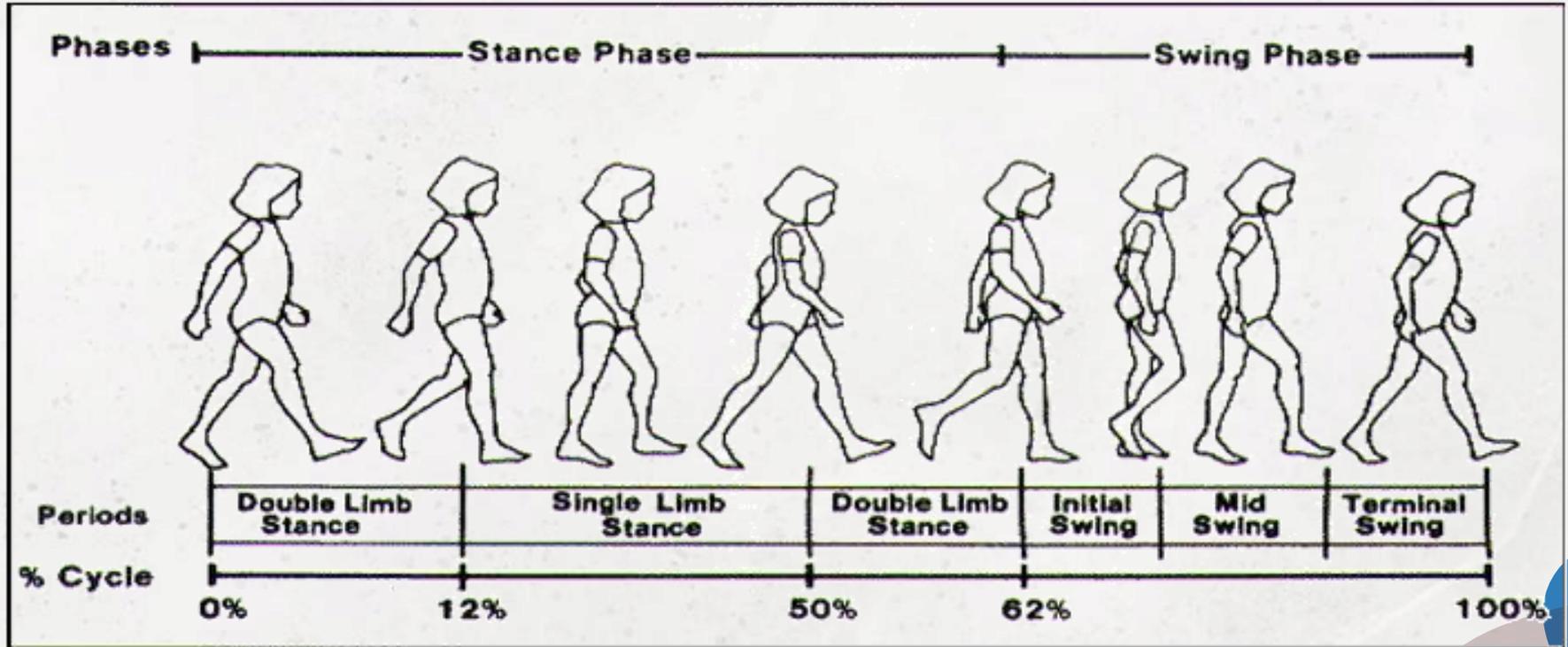
4- Heel-Off (Terminal Stance)

The heel lifts off the ground as the body moves forward.

5- Toe-Off (Pre-Swing)

The toes push off the ground, ending the stance phase and preparing for the swing phase.





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Swing Phase



1- Acceleration (Initial Swing)

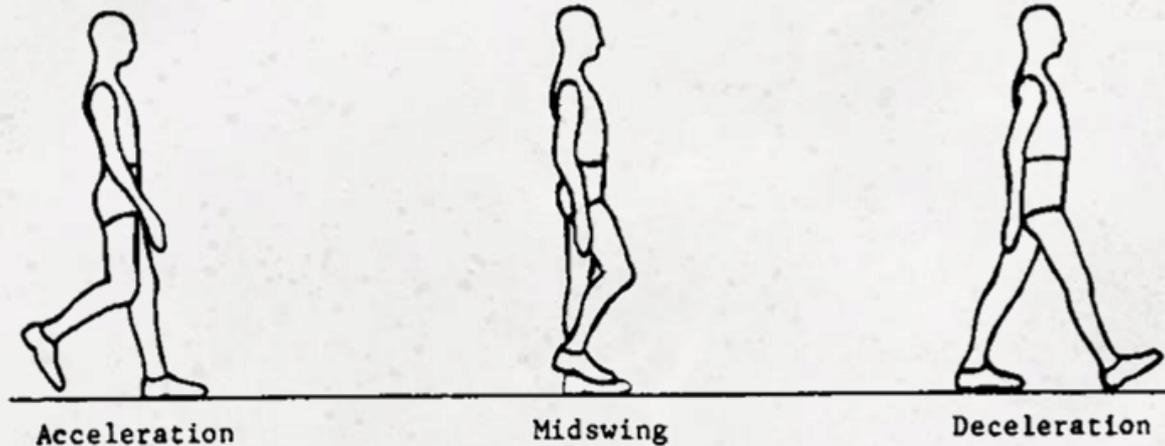
The foot lifts off the ground and begins moving forward.

2- Midswing

The swinging leg passes the stance leg in midair.

3- Deceleration (Terminal Swing)

The swinging leg slows down in preparation for heel contact.





➤ **Temporal Variables (Time-related)**

1. **Stance Time** – Duration the foot is in contact with the ground.
2. **Single Limb Support Time** – Time when only one foot is on the ground.
3. **Double Limb Support Time** – Time when both feet are in contact with the ground.
4. **Swing Time** – Duration the foot is off the ground.
5. **Stride and Step Time** – Time taken for one stride or one step.
6. **Cadence** – Number of steps per minute.
7. **Speed** – Distance covered per unit time.



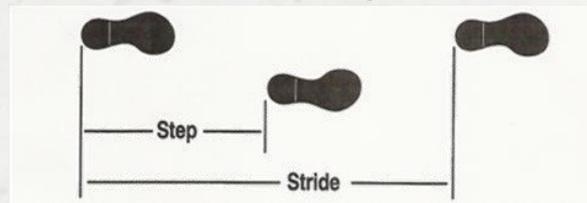
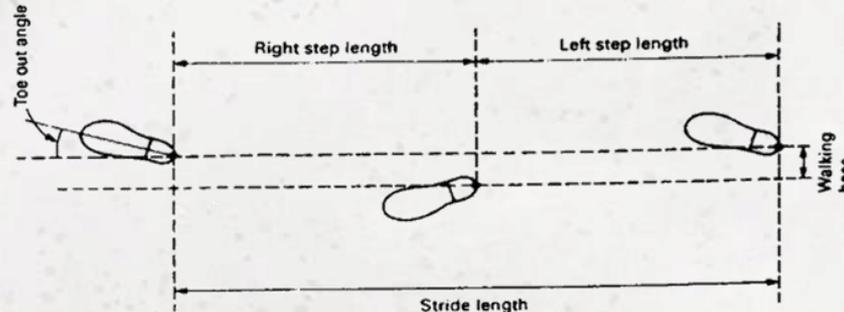
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Distance and Time Variables in Gait



➤ Distance Variables (Spatial-related)

1. **Stride Length** – Linear distance from the heel strike of one foot to the next heel strike of the same foot.
2. **Step Length** – Distance between corresponding successive points of heel contact of opposite feet.
3. **Width of Walking (Step Width / Base of Support)** – Lateral distance between the two feet during walking.





Forces influencing gait (most significant):

1. **Gravity** – Constant downward force acting on the body.
2. **Muscular Contraction** – Provides movement and stability during gait.
3. **Inertia** – Resistance of the body and limbs to changes in motion.
4. **Floor Reaction (Ground Reaction Force)** – Equal and opposite force exerted by the ground on the foot.



Path of the Center of Gravity (COG):

1. Located midway between the hips.
2. Positioned a few centimeters in front of the second sacral vertebra (S2).
3. Efficient gait occurs when the COG moves in a smooth, straight line, minimizing energy consumption.

